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Method and device for spraying of a material

The invention relates to a method for spraying of a material, in which method the material to be sprayed is introduced into a flame formed by means of a fuel gas and the flame is used to spray the particles of the material to be sprayed to a desired target.

Furthermore, the invention relates to a device for spraying of a material, which device is provided with means for introducing a fuel gas in such a way that the fuel gas forms a flame, and means for introducing the material to be sprayed into the flame, wherein the flame can be used to spray the material to be sprayed to a desired target.

It is known to spray a solid substance by means of a flame spray device. In this method, the substance to be sprayed is fed to the flame spray gun in the form of solid particles which are sprayed by the flame spray device to the desired target. When the particle size becomes smaller, the flame spray device is, however, easily soiled and clogged. Thus, it is difficult even to use the flame spray device to spray *e.g.* particles having a size of less than 20 micrometres, and the flame spray device is easily clogged and is expensive in its construction. Moreover, the solid matter to be sprayed is in several different phases during the flame spraying, being partly vapour, partly molten substance and substance molten in part, and when the substance is cooled, the final result is uneven.

US patent 3,883,336 presents a device in which silicon tetrachloride is supplied to a flame spray gun as a vapour by means of oxygen acting as a carrier gas. Further, said publication discloses that aerosol particles are sprayed from outside to the flame of the flame spray gun to manufacture glass. Said device has a poor coefficient of efficiency and the supply of silicon tetrachloride as a vapour by means of a carrier gas to the device is slow, since if there is an excess of silicon tetrachloride in proportion to the carrier gas, it is nucleated into larger droplets, and sufficiently small particles can thus not be sprayed.

It is an aim of the present invention to provide a method and a device whereby particles having the size in the order of a nanometre can be produced in a simple and inexpensive way.

The method of the invention is characterized in that the substance to be sprayed is introduced in liquid form to the flame and is

atomized by means of a gas substantially in the vicinity of the flame in such a way that the atomization and the flame formation take place in the same device.

Furthermore, the device of the invention is characterized in that the device is equipped with means for introducing a liquid substance to the flame and means for introducing a gas into the liquid to be sprayed in such a way that the gas atomizes the liquid to be sprayed into droplets substantially in the vicinity of the flame, wherein the atomization takes place in the same device as the flame formation.

The essential idea of the invention is that the substance to be sprayed by the flame spray device is introduced into the flame in liquid form in such a way that it is atomized into droplets by means of a gas substantially in the vicinity of the flame. Furthermore, the idea of a preferred embodiment is that the atomization takes place by means of a fuel gas bringing heat into the reaction.

The advantage of the invention is that very small particles can be produced fast, inexpensively and in a single step. Furthermore, the advantage of a preferred embodiment is that when a fuel gas bringing heat to the reaction is used for atomization, the burner for forming the flame does not become too large in size.

The invention will be described in more detail in the appended drawing, in which

Fig. 1 shows schematically the entity of a flame spray device according to the invention in a side view,

Fig. 2 shows schematically a device according to the invention in a side view and in a cross-section,

Fig. 3 shows schematically a nozzle part of the device according to the invention in a front view, and

Fig. 4 shows schematically another device according to the invention in a side view and in a cross-section.

Figure 1 shows the entity of a flame spray device according to the invention. A flame spray gun 1 is used to form a flame 8 to spray a substance to be sprayed. The required gases are supplied to the flame spray gun 1 along gas ducts 2, 3 and 4. Along the gas ducts 2, 3 and 4 are supplied the fuel gases forming the flame, the gas for atomizing the liquid to be sprayed, and possibly a gas for controlling the reaction. The number of the gas ducts 2, 3 and 4 is naturally

sufficient according to the number of gases that need to be supplied to the flame spray gun 1. The substance to be sprayed is supplied in liquid form to the flame spray gun 1, along a liquid duct 5. The liquid to be sprayed is transferred along the liquid duct 5 by pumping it for example with an injection pump 6. The transfer of the liquid to be sprayed along the liquid duct 5 can also be implemented for example by supplying the liquid from a pressure tank or in another way known as such. At the right end of the flame spray gun 1, seen in Fig. 1, there is a nozzle 7 where the fuel gases are ignited to produce a flame and where the liquid to be sprayed is atomized by means of an atomizing gas, wherein the atomizing takes place substantially in the vicinity of the flame 8. The liquid to be sprayed can be sprayed to a desired target, for example to glass 9. The device of Fig. 1 is used for producing very small particles, having a size in the order of magnitude of about one nanometre; therefore, when the particles are sprayed for example into glass 9, the particles penetrate into the glass, changing the glass structure in such a way that the colour of the glass is changed. The glass 9 can be either clear or coloured, and its material can be for example soda glass, semi-crystal or crystal glass, or borosilicate glass, or another corresponding material.

Figure 2 shows a flame spray gun 1 in a side view and in a cross-section. The reference numerals of Fig. 2 correspond to the reference numerals of Fig. 1. The liquid to be sprayed is supplied to the flame spray gun 1 along a liquid duct 5. From the liquid duct 5, the liquid is transferred to a liquid tube 5a in the centre of the flame spray gun 1. A gas for atomizing the liquid is led through a first gas duct 2 to a first gas tube 2a around the liquid tube. A second gas is led along a second gas duct 3 to a second gas tube 3a around the first gas tube 2a. Further, a third gas is led along a third gas duct 4 into a third gas tube 4a around the second gas tube 3a. The liquid tube 5a and the first, second and third gas tubes 2a, 3a and 4a are thus tubes arranged within each other. In a nozzle 7, the atomizing gas supplied via the first gas tube 2a atomizes the liquid supplied along the liquid tube 5a into droplets. Along the second gas duct 3 and further the second gas tube 3a, it is possible to supply for example hydrogen, and along the third gas duct 4 and further the third gas tube 4a it is possible to supply for example oxygen, wherein after the nozzle 7, the hydrogen and

oxygen react by forming a flame. Said flame sprays the liquid atomized into it to a desired target. The liquid to be atomized can be any aqueous or alcohol solution of a desired ion; for example, it is possible to use cobalt nitrate dissolved in alcohol or water. As the atomizing gas, it is advantageous to use an exothermic fuel gas, such as a mixture of oxygen and acetylene or another corresponding gas. To accelerate the combustion reaction, it is advantageous that also the liquid to be sprayed is exothermic, such as an alcohol solution. The first atomizing gas to be supplied via the first gas tube 2 can also be a gas used for forming the flame, such as hydrogen. In this case, oxygen is supplied via the second gas duct 3, wherein the hydrogen atomizes the liquid to be sprayed and reacts with oxygen by forming the flame of the flame spray gun 1. Thus a separate atomizing gas is not needed. In such a structure, the third gas duct 4 and the third gas tube 4a, respectively, are not necessary. Nevertheless, they can be used, if desired, to improve the control of the reaction, for example by supplying argon via the third gas duct 4 and further via the third gas tube 4a, wherein the argon will prevent the effect of external oxygen in the reaction. Naturally, it is obvious that when a separate atomizing gas is used in addition to the flame forming gases, such as hydrogen and oxygen, it is possible to supply a gas outside the flame for controlling the reaction, wherein this gas would be supplied by using for example the fourth gas duct and the fourth gas tube around the third gas tube 3a. It should be noted that for clarity, Fig. 2 shows the structure of the flame spray gun 1 in a larger scale than the real situation. To achieve effective atomizing, it is preferable to make for example the speed of the atomizing gas as high as possible. Thus, the orifices of the nozzle 7 are preferably made sufficiently small. Furthermore, the structure of the liquid tube 5a and the first gas tube 2a can be described in such a way that the tubes in question are, structurally, two hollow needles placed within each other.

Figure 3 shows the nozzle 7 in a front view. The reference numerals of Fig. 3 correspond to the reference numerals of Figs. 1 and 2. Figure 3 shows an opening at the end of the liquid tube 5a in the centre of the nozzle 7. Around the opening, the opening of the first gas tube 2a is visible. The gas supplied via the second gas tube 3a is shown to be led through the nozzle 7, via orifices 10. In a correspond-

ing manner, the gas supplied via the third gas tube 4a is led through the nozzle 7, via orifices 11. It is obvious that the size and geometry of the openings and orifices in the nozzle 7 can vary in a desired manner, but it is essential that the rates of the liquid and of the atomizing gas in the nozzle 7 are made as desired in such a way that the liquid to be sprayed can be atomized to sufficiently small droplets, wherein sufficiently small particles are obtained and, on the other hand, the rate of the gases forming the flame is sufficient.

Figure 4 shows another flame spray gun 1' according to the invention in a side view and in a cross-section. The reference numerals of Fig. 4 correspond to the reference numerals in Figs. 1 to 3. The device of Fig. 4 is provided with several liquid supply ducts 5b–5d. A different liquid can be supplied via each liquid duct 5b–5d. From the liquid ducts 5b–5d, the liquid is led via liquid tubes 5e–5g further to the nozzle 7. All the liquids to be sprayed are atomized in the nozzle 7. The separate liquid ducts 5b–5d prevent that the liquids to be sprayed react with each other before the flame.

The drawing and the description related to it is only intended to illustrate the idea of the invention. The details of the invention may vary within the scope of the claims. Therefore, it is possible, for example, to spray particles produced by the method and device of the invention into a variety of materials, such as metals or ceramics, to achieve a desired effect.